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WATER TREATMENT AT COUNCIL GROVE, KANSAS[1]

By Louis L. Tribus

In March, 1915, the Association published a brief paper descriptive of the then recently remodeled water works station at Council Grove, Kansas, the special item of current interest being that portion of the plant treating the raw river water. The feature of novelty lay in the plan for successive application of dissolved coagulant, as the water passed from one part of the system to another. The use of coagulant could be very closely regulated as river conditions required and as the water exhibited its very varying characteristics and behavior while going through the different original stages from sometimes serious foulness to clear and safe potability.

After three years of operation, it may be of interest to note some of the results secured under the peculiar difficulties that have had to be met.

The Neosho River has but a limited watershed; it flows largely over a rocky bed, traversing a black soil belt but sparsely wooded. The general region is subject to sudden and violent storms which are without regularity as to season. These conditions produce high floods and varying turbidities, at times well over 5000 parts per million. How much more than that is not recorded, for the local testing apparatus has no higher range. The river flow varies from almost nothing (a slight spring supply) to an over-abundant maximum, running from 7 to 15 feet in depth over the dam, having a crest length of 100 feet or over.

Alkalinity ranges from a minimum of 48 to a maximum of 365, decreasing as the river rises.

With the silt burden come also varying colloidal troubles.

The water temperature fluctuates from a minimum of 33° to a maximum of 86°.

The bacterial content has naturally a very wide range, due to the nature of the watershed and varying character of the flow of the river.

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[1] Read at the St. Louis Convention, May 14, 1918.

Algae are prolific at times in the summer season when the river is low; copper sulphate is used sparingly, but with success, in the lower reservoir. The natural quality of the water at low river stages is quite fair, although high in permanent hardness, which lessens somewhat as storm waters raise the river level.

It can be well imagined that with these characteristics, the treatment problem is one that can not be left to unintelligent handling.

The two successive superintendents of the plant have taken very great personal interest in its operation, endeavoring constantly to not only secure the delivery of an effluent that would be as near perfect as possible, but to reduce costs at the same time.

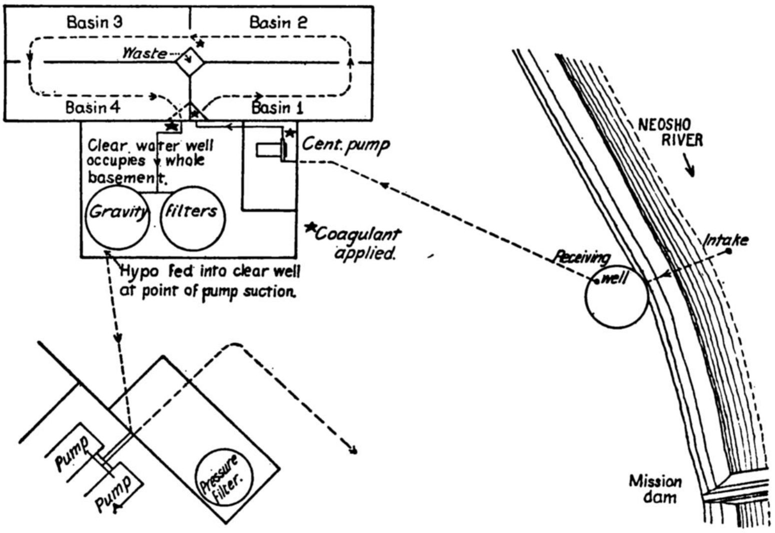

FIG. 1. COURSE OF WATER THROUGH PURIFICATION PLANT

The water flows from the river into a reception well in which considerable deposition of suspended matter takes place. From this a low-lift centrifugal pump raises it to the first of a series of four basins. At the pump it can receive a first dose of liquid sulphate of alumina, which becomes pretty thoroughly mixed in the discharge pipe before entering the first basin near the bottom through a triangular down-chute.

At this point a second dose can be given. The water then passes the length of basin 1 and through a low-level submerged opening enters basin 2. Passing through this, a third dose can be added just as it reaches basin 3 through a second submerged opening, placed at a higher level than that between basins 1 and 2. Flowing through basin 3 and into basin 4 at a still higher elevation, though still submerged, the water finds, at the farther end, the inlet to the filters, where a fourth dose of coagulant can be added.

It was found in the early stages of experimenting that in a turbid stage of the river the whole charge of coagulant at the pump or at basin 1 alone, was ineffective, for the globules of aluminum hydrate became coated with mud long before full service had been rendered, consequently practically untreated water passed to the filters. If, however, the charge was sub-divided and applied at points as observation showed necessary, each reached the water at a time when additional treatment was needed, and consequently before flowing upon the filters a large proportion of the suspended matter had been thrown down. There are cross-wall baffles in each of the basins which exert some influence in checking flow and causing deposition of solids.

The relative deposition of solids in the different basins under different combinations of treatment indicates very clearly the value of successive and cumulative attention. Cleaning has not been as systematic as could be desired, so the quantities of accumulations removed could not well be compared with the rates of flow and coagulant used, as it would be interesting to learn and may some day be studied. The gross use of coagulant in the sum of the separate doses has nowhere nearly equalled the quantity that would have been needed with the raw water treated at but one point.

Very perplexing in the early operations was the experience with large doses of coagulant. It seemed as if the turbidity would not yield; apparently no floc formed and the filters soon became choked. Then suddenly, action would begin and all would go satisfactorily and the results could thereafter be secured with very much smaller doses.

Temperature and alkalinity changes also exert a decided influence upon the purifying action, though studies have not yet been sufficient to standardize the treatment and reach definite conclusions.

It has been impossible, for financial reasons, to employ a chemist regularly, so that operations, other than those determined by turbidity and alkalinity, have depended upon the operator's judg-

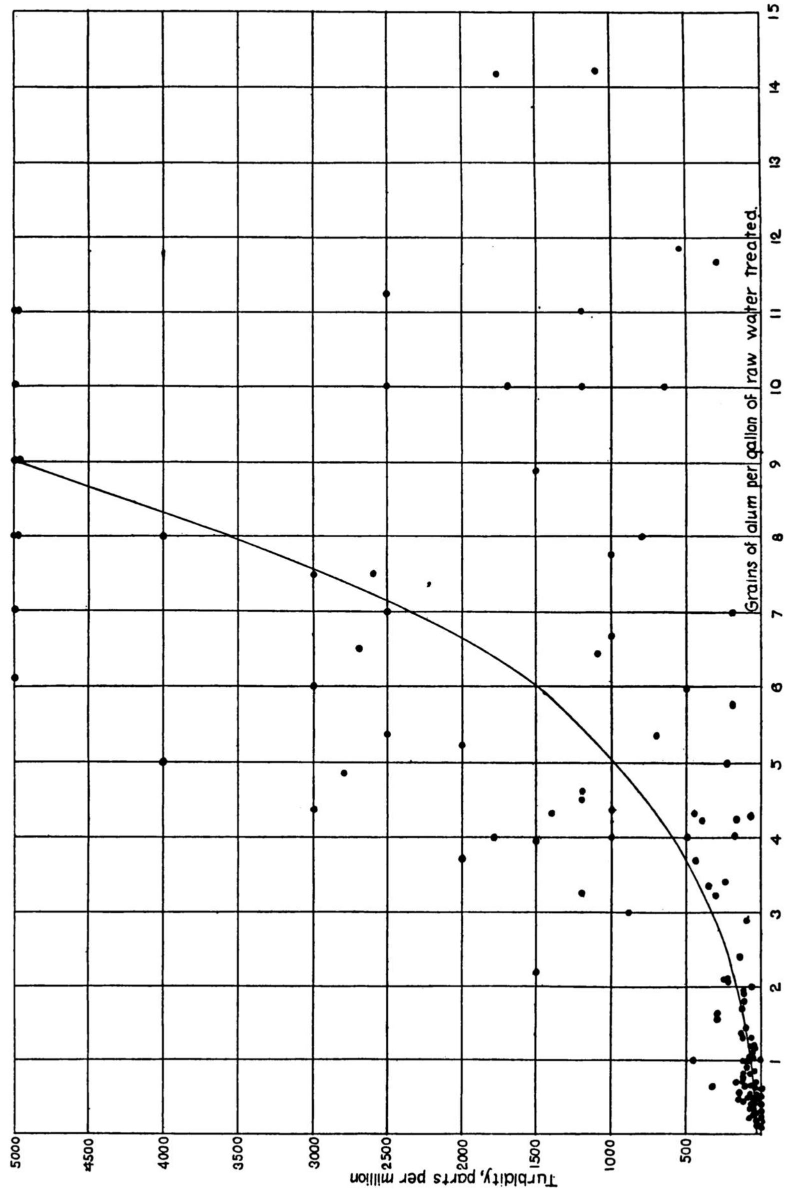

FIG. 2. 150 TYPICAL DAILY READINGS; TURBIDITY AND ALUM

ment, which has been largely controlled by the show of floc in the basins or on the filters and of course by the appearance of the filtered effluent.

Just as the water is drawn from the clear well for delivery by the main pumps into the city system, it receives dissolved hypochlorite, to the extent of 2 to 2½ pounds per day (dry chemical) for the 250,000 to 350,000 gallons of water pumped or about 10 pounds per million gallons ordinarily. This renders the water practically sterile, though the preceding operations remove the bacteria to a very satisfactory degree.

Weekly samples have been sent to the headquarters of the State Board of Health at Lawrence, where regular analyses are made with a view particularly to noting the presence of pathogenic bacteria and the values of turbidity and alkalinity. The reports received following such examination serve as a fair guide to the superintendent and give him a very good idea as to his success in handling the plant, confirming his own observations or causing him to use greater care if danger is indicated.

In the earlier weeks of operation following construction, the use of sulphate of alumina sometimes was as high as 20 grains per gallon of water pumped, but during 1916 and 1917, even with several periods of very high turbidity, the maximum was but 11 on one occasion and 9 on another; otherwise nothing above 7 in any of the flood periods, while the usual total rate has been considerably less than one grain per gallon.

With the exception of a few single days when the turbidity in the final effluent reached 30 parts per million, it has normally been zero. The successive improvement of the water, basin by basin, has very greatly eased the work of the filters, and hence in turn saves a large use of filtered water for back washing. The filters are of the open gravity type, the washing being aided by agitation with rotating stirrers. The wash-water pressure has been too variable for the best results, but a regulating valve is to be installed and perhaps a meter, so that future betterment should follow.

Upon the official tests of the plant, as well as in later operations, the bacterial removal by the basins and filters proved very satisfactory, through as before mentioned, as a final safeguard hypochlorite is used in small quantity.

The State Board of Health began making its tests in July, 1915; out of 102 reports since then received, 85 stated the water to be in

The test required for the filtered water shall be a reduction of bacterial content of at least 98 per cent from the content in the raw water, except that when the total number of bacteria is less than 3500 per cubic centimeter in the raw water, the filtrate must not contain in excess of 75 per cubic centimeter.

TABLE 1

Bacterial reduction in Council Grove treatment plant

DATE OF REPORT	BACTERIA PER CUBIC CENTIMETER		DATE OF REPORT	BACTERIA PER CUBIC CENTIMETER		DATE OF REPORT	BACTERIA PER CUBIC CENTIMETER	
	Raw water	Filtrate		Raw water	Filtrate		Raw water	Filtrate
1915			*1916*			*1917*		
July 22	5,000	750	May 8	5,000	25	Mar. 19	80	45
July 31	3,000	120	May 12	300	60	Mar. 23	120	50
Aug. 5	2,000	50	May 20	1,900	310	Apr. 3	40	20
Aug. 13	1,200	30	June 3	21,000	60	Apr. 9	60	15
Aug. 19	82,000	22	June 16	2,000	60	Apr. 13	50	30
Aug. 30	4,000	100	June 26	6,000	30	Apr. 27	3,710	80
Sept. 4	3,000	75	July 6	600	460	May 7	1,360	20
Sept. 9	460	130	July 14	500	10	May 18	600	11
Sept. 18	450	15	July 20	1,900	70	May 25	450	18
Sept. 27	65,000	16	July 28	300	10	June 7	15,000	65
Oct. 6	92,000	42	Aug. 3	300	150	June 11	10,000	100
Oct. 11	27,000	410	Aug. 19	4,000	1,000	June 21	150	50
Oct. 15	300	25	Aug. 26	1,400	400	June 28	300	5
Oct. 22	70,000	30	Sept. 2	1,400	150	July 10	150	25
Nov. 2	1,900	26	Sept. 9	900	14	July 13	2,500	40
Nov. 8	3,100	64	Sept. 15	2,000	200	July 18	400	10
Nov. 12	1,600	30	Sept. 23	250	15	July 28	600	60
Nov. 22	4,500	25	Sept. 30	1,600	20	Aug. 4	1,500	150
Nov. 29	420	16	Oct. 7	90	15	Aug. 9	1,900	175
Dec. 4	200	15	Oct. 13	150	6	Sept. 5	1,800	8
Dec. 13	400	70	Oct. 20	200	16	Sept. 15	15	1
Dec. 17	1,400	25	Nov. 4	900	35	Oct. 6	750	550
1916			Nov. 11	500	30	Oct. 15	700	5
Jan. 17	3,000	50	Nov. 17	2,000	10	Oct. 20	200	9
Feb. 3	11,000	120	Nov. 24	800	90	Oct. 25	1,900	5
Feb. 11	40,000	35	Dec. 18	630	19	Nov. 3	1,000	8
Feb. 21	4,100	130	*1917*			Nov. 9	650	15
Feb. 26	1,400	25	Jan. 10	3,400	200	Nov. 16	900	125
Mar. 7	6,300	80	Jan. 15	1,400	290	Nov. 24	600	20
Mar. 13	250	100	Jan. 26	180	15	Dec. 3	1,000	50
Mar. 18	900	30	Jan. 28	400	220	Dec. 7	500	40
Mar. 23	1,000,000	840	Feb. 10	80	30	Dec. 27	225	90
Apr. 13	500	50	Feb. 17	70	20	*1918*		
Apr. 17	2,500	120	Feb. 23	150	26	Feb. 1	250	5
Apr. 23	850	225	Mar. 5	90	60	Feb. 14	450	55
May 1	1,500	800	Mar. 12	50	30	Feb. 18	150	15

"excellent," "very good," "good" and "fair" condition. Of the remaining 17, only two condemned the water, the others, though reporting "poor" rather raised question as to details of treatment, as the best results were not being secured. The bacterial count varies very greatly in the raw water and colon bacilli are usually indicated. The Board of Health makes its tests usually of the raw water and the finished effluent as taken from a service tap at the station. The original acceptance test of the filters was made subject to its approval.

The contract paragraph concerning bacterial removal is repeated on page 443, so that it may be compared with the results of the 2¾ years succeeding, as reported by the chemists of the Board.

Of the 105 bacterial reports, 81 show results handsomely within the test conditions, and but few of the others indicate any special deficiency in action. At times of heavy turbidity, when bacterial count runs specially high, the operations have been signally efficient; this indicates, perhaps, more special care in operation, due to the difficulty in securing a clear filtrate.

Taken as a whole, therefore, without a resident chemist, with several changes of station engineer and assistant, the breaking in of inexperienced men each time, and during quite a portion of 1917 with a superintendent in ill health, the showing is quite favorable to the working of the plant.

In a few tests which have been made, the percentage of successive betterment through treatment in the basins and the filters has been very interesting, but no consistent regular record has been kept, due to lack of sufficient time of the superintendent or engineer.

The operation of the plant as a whole has abundantly justified its design, and responds effectively to good care; though the filter strainers clog rather more than is desired and may have to be changed in type before long.

The diagrams illustrating this paper, other than figure 1, a plan showing course of the water from river to consumers, are made up from typical daily notations of turbidity, alkalinity and grains per gallon of sulphate of alumina used in the treatment.

From 1100 observations recorded during 1915 to 1917 inclusive, 150 have been selected, regardless of season, so as to cover so far as possible several readings at each rate throughout the whole range of variation.

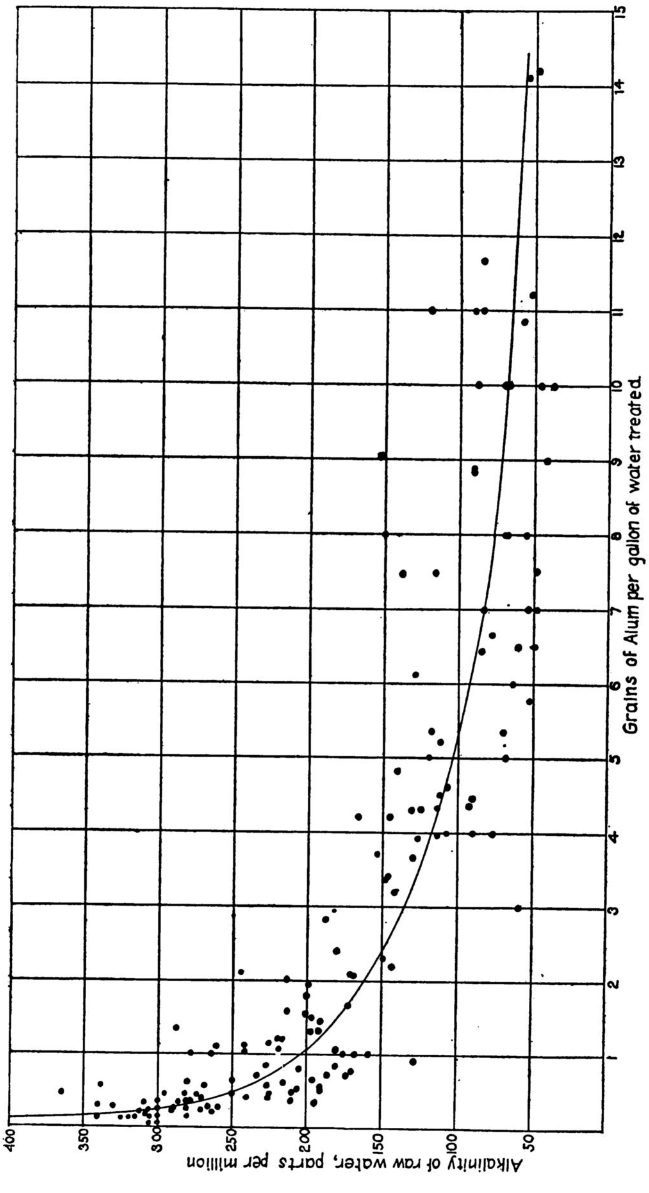

Fig. 3. 150 Typical Daily Readings; Alkalinity and Alum

The diagram showing "turbidities" compared with "grains of alum," figure 2, does not indicate clearly any particular law, though a suggestive curve, is shown, more based on general knowledge of the plant than determined from a close study of the turbidities. This is not surprising, for most of the turbidity is caused by heavy suspended matter carried by the high velocity in flood stage and quite ready to settle when brought to reasonable rest.

Occasionally a bad colloidal condition obtains, when the hydrate of alumina finds hard work to perform, but there has been little opportunity to study it carefully as a separate problem.

The diagram comparing "alkalinity" with "grains of alum," figure 3, indicates very nicely a relationship that permits the selection of a fair, smooth curve to represent normal working, except when some special river condition upsets all theories and gives several hours of perplexing activity and experiment.

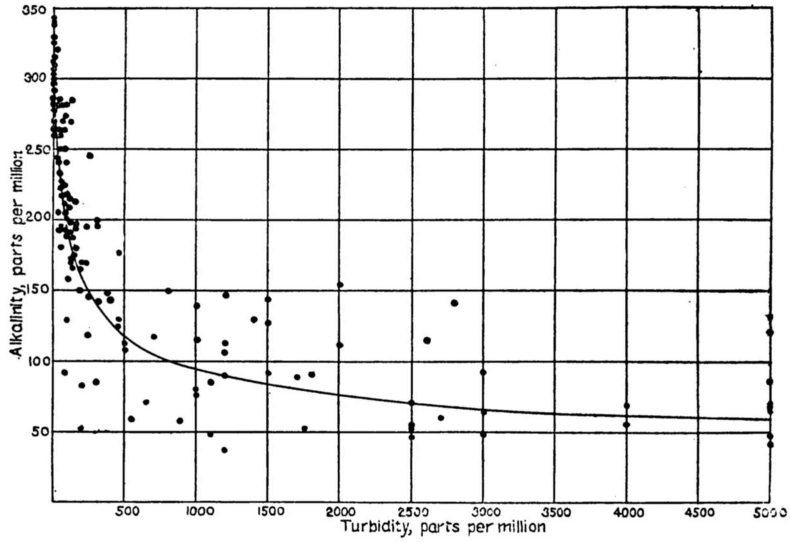

FIG. 4. 150 TYPICAL DAILY READINGS; ALKALINITY AND TURBIDITY

The remaining diagram, comparing "alkalinity" and "turbidity," figure 4, indicates a chance for a fairly good curve, but one not specially conclusive in nature, and possibly to be changed materially as further observations are made.

The higher alkalinities prevail generally in the winter season, during the lowest river stages, when turbidities would naturally not run high, even with fair-size floods, for frozen lands do not yield so readily to erosion.

In all of the 150 records taken for plotting, the effluents were reported as having zero turbidity.

It is rather an interesting commentary on human nature, however, that while the water company has furnished safe filtered water for twenty years and brilliantly clear, sterilized, filtered water for three years, there are still many residents who hold to the rain tanks with roof washings, and shallow back-yard wells. Rates have been held at the low figures established 30 years ago, based on the low schedules of the city of St. Louis. A change, however, must shortly be made, so as to give more adequate return upon the investment in use.

It is often in the smaller plants that some of the most perplexing problems arise for the water works engineer to solve. This plant has been very interesting to the author, for it has illustrated many of the difficulties of operating a water treatment system and well repaid his occasional trips to examine its workings, suggest improvements, and generally consult face to face with the operating officials, during 20 odd years of advisory service.